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Scrutiny of Combined Cycle with Innovation in Gas Turbine Operating Parameters

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ABSTRACT

This paper shows that the effect on the factor like combined cycle efficiency, fuel consumed(kg) per 100kg of air, gas turbine outlet temperature & work obtained from combined cycle with the compression ratio. But three factor like work obtained from combined cycle, combined cycle efficiency & fuel consumed (kg) per 100kg of air are how much effected with the fluctuation in the turbine inlet temperature and ambient air temperature. The performances of gas turbine depend on installation site, environmental conditions mainly on air temperature; variations of air temperature have a great effect on the efficiency and the power generated by the plant. Gas turbine output depends on mass flow rate. Ambient temp. Affects the air flow rate, work and power output, heat rate and exhaust temp. Air density is inversely to the dry bulb temp. Result shows that as the compression ratio will increase the efficiency will increase in less amount. Turbine inlet temperature (TIT) is being fixed by the metallurgical limit. As the TIT increase work output and efficiency will also increase. Turbine outlet temperature decreases with increase in compression ratio. Work output increase up to a pressure ratio of 18 after that it start diminishing.

Key words: cycle, operation, turbine, parameters.

S.NO.	SYMBOL	NOTATION
1.)	Temp.	Temperature
2.)	Ach	Restricted Dead State
3)	gt	Gas Turbine
4.)	hrsg	Heat Recovery Steam Generator
5.)	X_k	Mole Fraction of Substance
6.)	COP	Coefficient of Performance
7.)	Cv	Specific Heat at Volume (KJ/KgK)
8.)	D	Diameter(m)
9.)	E	Energy(KJ)

INTRODUCTION

Combined Cycle Power Plants (CCPP) are those which have both gas and steam turbines supplying power to the network. Combined cycle power plants employ more than one thermodynamic cycle .Combined cycle units are made up of one or more such gas turbine, each with a waste heat steam generator arranged to supply steam to a single steam turbine, thus forming a combined cycle block or unit. In electric power generation a combined cycle is an assembly of heat engines that work in tandem from the same source of heat, converting it into mechanical energy, which in turn usually drives electrical generators. In combined cycle the heat rejected by the topping plant is absorbed by the bottoming plant. The principle is that after completing its cycle (in the first engine), the working fluid of the first heat engine is still low enough in its entropy that a second subsequent heat engine may extract energy from the waste heat (energy) of the working fluid of the first engine. By combining these multiple streams of work upon a single mechanical shaft turning an electric generator, the overall net efficiency of the system may be increased by 50 – 60 percent.

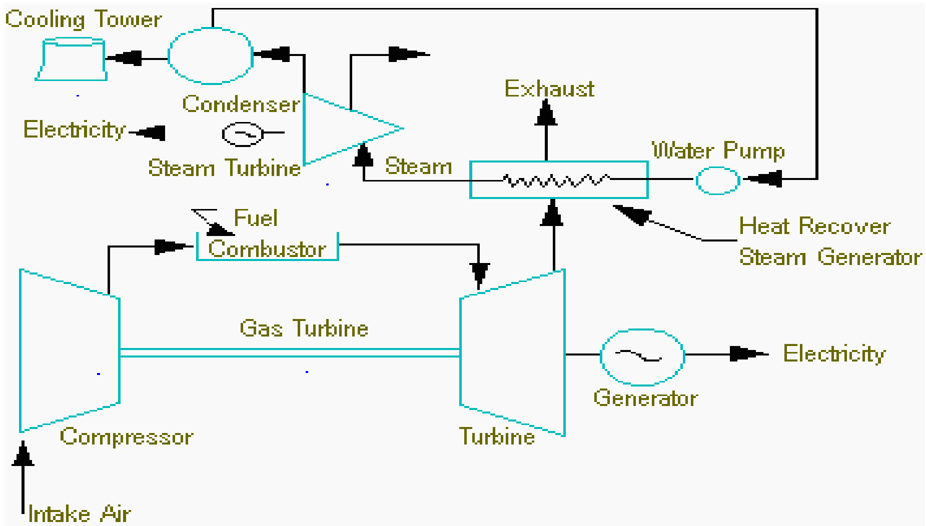

Figure 1: Diagram for the Combined Cycle Power Plant

In a combined cycle power plant (CCPP), or combined cycle gas turbine (CCGT) plant, a gas turbine generator generates electricity and heat in the exhaust is used to make steam, which in turn drives a steam turbine to generate additional electricity. This last step enhances the efficiency of electricity generation.

Literature Review

Najjar & Akyurt (1994) [1] reviewed various types of combined cycles, including repowering, integrated gasification and other advanced systems. According to this study: 1). Combined cycles boost power output and efficiency to levels that are considerably above those of steam power plants 2). Repowering, when converting an existing steam plant to combined cycle, offers savings in capital cost as compared to new construction 3). Combined cycle, when integrated with coal gasification, holds promise in converting coal into electric power in an efficient, economical and environmentally acceptable manner 4). The air-bottoming cycle (ABC), chemically recuperated gas turbine, compressed air energy storage (CAES) and compressed air storage humidification (CASH) are among advanced concepts with promise for combined cycle applications.

Horlock (1995) [2] based on thermodynamic considerations, outlined developments of 1970s and 1980s and future prospects of combined-cycle power plants. The main focus was on: (i) raising the mean temperature of heat supply; (ii) minimizing the irreversibility within the heat recovery steam generator; (iii) keeping the heat loss between the two plants as low as possible.

S. Cafaro (2010) [30] this paper presents research project carried out by TPG (Thermochemical Power Group) of University of Genoa to develop innovative monitoring and diagnostics procedures and software tools for software-aided maintenance and customer support. This work is concerned with preliminary outcomes regarding the thermoeconomic monitoring of the bottoming cycle of a combined cycle power plant, using real historical data. The software is able to calculate functional exergy flows (y), their related costs (c) (using the ◂plant▸ functional diagram.

Research methodology- Steps of research methodology is follow as:

- In the area of combined cycle, cooling system and STIG an exhaustive Literature Review is under progress.

- In the present analysis I use the input variable. on the basis of my work. So I take three variable turbine inlet temperature, gas turbine compressure ratio & ambient air temperature to find out effect on the fuel consumed in kg per 100kg of air, work obtained from combined cycle and efficiency of combined cycle. So those equations which are effected with the variation of these inputs are collected at a one place. These equation are taken from existing system. To obtained output, making a programme in the matlab. Development of mathematical modeling for topping and bottoming cycles, STIG and IAC systems. a mathematical model as 'a representation of the essential aspects of an existing system (or a system to be constructed) which presents knowledge of that system in usable form..

RESULT ANALYSIS

Gas turbines used in combined cycle plants have pressure ratios less than 15. In the present analysis cycle compression ratio is varied from 8 to 20. The compression ratio is kept in between these two ratios because In actual practice a gas turbine have maximum efficiency at different pressure ratio than that for maximum work output. The compression ratio is directly proportional to the maximum temp. at the outlet. As the compression ratio is increased the maximum temperature at the outlet of compressor is increased. The requirement of fuel is decreased as we fix turbine inlet temp. Gas turbine inlet temperature is fixed by the thermal stress bearing limit of the turbine blade material. If you want to increase the compression ratio of the gas turbine the size of the blade will be larger and inertia force will increase. To withstand high inertia force, a blade of strong base is required. The waste heat coming out from the gas turbine may be utilized in HRSG to generate steam which will be passed from the steam turbine to generate power in combined cycle power plant.

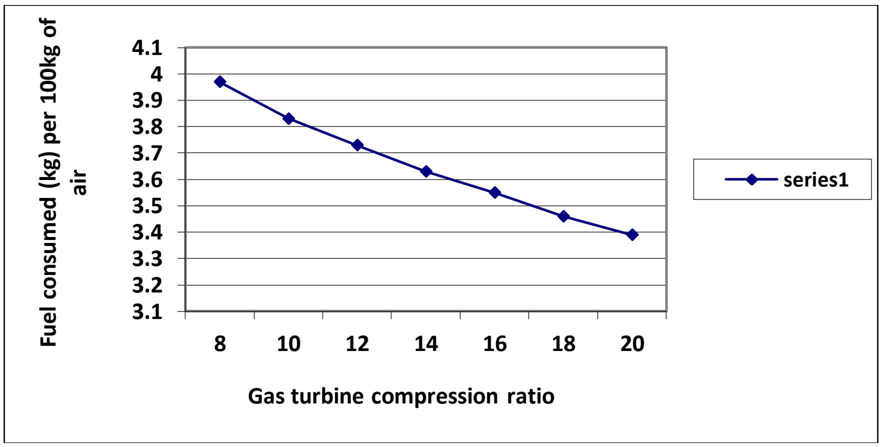

Figure.3: Change in fuel injected in combustion chamber with change in gas turbine compression ratio.

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FUTURE SCOPE

- As further work Methodology is needed for conversion of a **Combined Cycle Power Plant** to an Integrated Solar **Combined Cycle** (ISCC). And determine the effect on efficiency & also calclucation of electricity generated from solar plant.
- Today advance combined cycle power plant operate alongside increasing level of wind turbine and solar energy power plants, and are subjected to daily start up peaking operation and load following to smooth out fluctuations in renewable solar and wind generation. Advanced combined cycle plants have been designed with features to support this new trend for increased cyclic operation and turndown capability.
- HRSG drums with lower thickness to accommodate rapid heating and cooling.
- How do you design a **combined cycle power plant** As a result of it , installation **work** of main components can start earlier, and the plant can be finished faster.

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